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ABSTRACT

An optional guidebook designed to follow the study of Mathematical Structures, this booklet specifies minimum course content for introductory geometric constructions and concepts. It includes the use of geometry tools, and covers basic geometric figures and congruence, angles, perpendiculars and parallels, triangles, perimeter and circumference, area and volume, symmetry, and similarity. Overall course goals are listed, teaching strategies suggested, performance objectives stated, a course outline provided, and textbook references keyed to the outline are included. Test items are given, plus an annotated listing of seven references. (DT)

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Geometric Construction

5211.61
5212.61
5213.61

Mathematics

SE 017 028

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1971

ED 084163

QUINMESTER MATHEMATICS

COURSE OF STUDY

FOR

GEOMETRIC CONSTRUCTION
5211.61
5212.61
5213.61

Written by
Jack Waite
for the

DIVISION OF INSTRUCTION
Dade County Public Schools
Miami, Florida 33132
1971-72

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PREFACE

The following course of study has been designed to set a minimum standard for student performance after exposure to the material described and to specify sources which can be the basis for the planning of daily activities by the teacher. There has been no attempt to prescribe teaching strategies; those strategies listed are merely suggestions which have proved successful at some time for some class.

The course sequence is suggested as a guide; an individual teacher should feel free to rearrange the sequence whenever other alternatives seem more desirable. Since the course content represents a minimum, a teacher should feel free to add to the content specified.

Any comments and/or suggestions which will help to improve the existing curriculum will be appreciated. Please direct your remarks to the Consultant for Mathematics.

All courses of study have been edited by a subcommittee of the Mathematics Advisory Committee.

CATALOGUE DESCRIPTION

An optional quin to follow the study of Mathematical Structures, which will reinforce ratio, proportion, fractions, problem solving, and decimals. Includes the use of geometric tools, recognition of fundamental figures, geometric constructions, area, and volume.

Designed for the student who has mastered the skills described in Mathematical Structures 1 and 2.

TABLE OF CONTENTS

	Page
Overall Goals	3
Key to State Adopted Texts	3
Introductory Strategies	4
Performance Objectives	5
Outline, Strategies, and References	
I. Basic Geometric Figures and Congruence	8
II. Angles	9
III. Perpendiculars and Parallels	11
IV. Triangles	12
V. Perimeter and Circumference	14
VI. Area and Volume	15
VII. Symmetry	16
VIII. Similarity	17
Sample Test Items	18
Annotated Bibliography	28

OVERALL GOALS

The student will:

1. Use the basic tools of geometric construction.
2. Use basic measuring instruments.
3. Recognize basic geometric figures.
4. Recognize the properties of basic geometric figures.
5. Reinforce skills with fractions, decimals, percents, ratio, and proportion as they are applied to problem solving involving similarity, area, and volume.

KEY TO STATE ADOPTED TEXTS

B Bernstein, et al. Trouble Shooting Mathematics Skills. New York, New York: Holt, Rinehart and Winston, Inc., 1963.

* G Gold and Carlberg. Modern Applied Mathematics. Boston, Mass.: Houghton Mifflin Co., 1971.

J Johnson, et al. Activities in Mathematics: (AIM). Glenview, Ill.: Scott, Foresman and Co., 1971. (Second Course, Geometry).

* M McSwain, et al. Mathematics 8. River Forest, Ill.: Laidlaw Brothers, 1964.

SK Skeen, et al. Modern Mathematics I. Syracuse, New York: The L. W. Singer Co., Inc., 1966.

* So Sobel and Maletsky. Essentials of Mathematics, Book 3. Boston, Mass.: Ginn and Co., 1969.

* So2 Sobel and Maletsky. Mathematics II. Boston, Mass.: Ginn and Co., 1971.

* Considered to be good as textbook. Others are good for supplementary materials.

INTRODUCTORY TEACHING STRATEGIES

1. Don't neglect to use direct measurement. This serves a very practical and interesting purpose.

2. The history of geometric construction should not be neglected.

3. The sequence of the course can be very flexible.

4. There should be a liberal use of geometric models throughout the course. This is a great interest factor for the students and strengthens the recognition of properties.

5. Students should maintain a notebook.

6. Students need the following basic tools: compass, protractor, straightedge, and ruler. Try to avoid the use of a ruler as a straightedge.

7. Introduce special measuring instruments that may be borrowed from your Industrial Arts Department. The Industrial Arts teacher is a tailor-made source of reference for special tools of industry.

PERFORMANCE OBJECTIVES

I. Basic Geometric Figures and Congruence

The student will:

1. Exhibit or identify the symbols for and models of points, lines, planes, rays, segments, half-lines, half-planes and angles.

2. Determine if two figures are congruent by using tracings and slide, flip, and turn motions.

3. Construct congruent segments
   a. using a ruler
   b. using a compass and straightedge.

4. Bisect a segment
   a. using a ruler
   b. using a compass and straightedge.

II. Angles

The student will:

1. Construct congruent angles
   a. using a protractor and straightedge
   b. using a compass and straightedge.

2. Bisect an angle
   a. using a protractor and straightedge
   b. using a compass and straightedge
   c. using a straightedge only.

3. Trisect an angle using a protractor and straightedge.

4. Solve problems involving complementary and supplementary angles.

III. Perpendiculars and parallels

The student will:

1. Identify definitions and models of parallel and perpendicular lines and segments.

2. Construct the perpendicular bisector of a segment
   a. using a protractor and ruler
   b. using a compass and straightedge.

3. Construct perpendicular lines or segments
   a. using a protractor and straightedge
   b. using a compass and straightedge (through a point on a line and a point not on a line.)

4. Construct parallel lines or segments
   a. using a protractor and straightedge
   b. using a compass and a straightedge.

5. Divide a given segment into a given number of congruent segments using a compass and straightedge only.

IV. Triangles

The student will:

1. Classify triangles as right, obtuse, acute, scalene, isosceles, equilateral.

2. Construct congruent triangles
   a. using a ruler and protractor
   b. using a compass and straightedge.

3. Use the Pythagorean Theorem to solve problems.

V. Perimeter and Circumference

The student will:

1. Classify
   a. curves as closed curves, simple closed curves, polygons, circles
   b. polygons as triangles, quadrilaterals, pentagons, hexagons, decagons
   c. quadrilaterals as trapezoids, parallelograms, rectangles, rhombuses, squares.

2. Construct squares, rectangles, parallelograms, and hexagons
   a. using conventional methods
   b. using geometric methods.

3. Find the perimeter of any polygon when given sufficient information.

4. Find the radius, diameter, or circumference of a circle when given sufficient information.

5. Create at least one original geometric design.

VI. Area and Volume

The student will:

1. Use formulas to solve problems involving areas of plane figures.

2. Classify solid figures as prisms, cylinders, cones, pyramids, spheres.

3. Use formulas to solve problems involving the surface areas of solid figures.

4. Use formulas to solve problems involving the volumes of solid figures.

VII. Symmetry

The student will:

1. Identify figures that have at least one line of symmetry.

2. Exhibit at least one axis or line of symmetry of a symmetrical figure.

VIII. Similarity

The student will:

1. Identify definitions or models of similar figures.

2. Use ratio and proportion to solve problems involving similar figures.

OUTLINE, STRATEGIES, AND REFERENCES

I. Basic Geometric Figures and Congruence

A. Introductory history of measurement

B. Geometric figures

1. Names
2. Symbols

C. Congruence

1. Definition and symbol
2. Determining if two figures are congruent

a. Slides
b. Turns
c. Flips

D. Use of construction tools

1. Straightedge
2. Ruler
3. Compass
4. Protractor

E. Copy and bisect line segments

1. Using a ruler
2. Using straightedge and compass

Vocabulary: point, line, plane, segment, ray, half-line, half-plane, angle, ruler, straightedge, compass, protractor, bisect, congruent, midpoint.

Suggested Strategies

1. This is a good time to introduce the history of measurement. The history provides an excellent opportunity for special group projects or special assignments. It also provides good material for bulletin boards.

2. Congruence should be treated informally. Have students match figures by using tracings to

determine whether two figures are congruent. Don't forget to introduce the symbol, $\cong$, too.

3. Interest in geometric construction may be created by having students compare measurements made using a ruler and those made using geometric construction methods.

4. It is hoped that the student will want to know why the perpendicular bisector bisects a segment. Develop this in Unit 3.

5. This unit should not be drawn out too much. It is mainly an introductory unit--used to create interest.

References

	B	G	M	SK	So2	So
Chapters	10	2,3,6,7	8,10	8,9	4	3,7,8,9

II. Angles

A. Naming angles

B. Types of angles

1. Acute
2. Obtuse
3. Right
4. Straight
5. Reflex

C. Pairs of angles

1. Vertical
2. Adjacent
3. Complementary
4. Supplementary
5. Congruent

D. Measure of angles

1. Using a protractor
2. Estimation without using a protractor

E. Copying angles

1. Using protractor and straightedge
2. Using compass and straightedge

F. Bisecting an angle

1. Using protractor and ruler
2. Using compass and straightedge
3. Using a straightedge only

G. Trisecting an angle

1. Using a protractor
2. Impossibility of trisecting angles with a compass and straightedge only

H. Problems involving angles

Vocabulary: acute, obtuse, right, straight, reflex, vertical, adjacent, complementary, supplementary, congruent angles, trisect

Suggested Strategies

1. Make liberal use of the tools of industry. Check with the wood and metal shop teachers. They have an abundance of knowledge on use of the carpenter's square, T-bevel, etc.

2. Don't neglect problem solving. Supplements and complements allow for an abundance of problems.

3. Discussion of the trisection of an angle can be stimulating and has great motivation value.

4. To bisect an angle with straightedge only, two parallels are drawn. Place the straightedge along one ray and draw a segment using the opposite edge as a guide. Repeat for the other ray. The two segments intersect on the bisector of the angle.

5. Use the skills students acquire in measuring angles to show that vertical angles are equal. The student practices with the protractor and compass and also discovers an important property.

References

	B	G	M	SK	So2	So
Chapters	---	2,3,6,7	8,10	8,9	4	7,8,9

III. Perpendiculars and parallels

A. Definitions

B. Models

C. Constructions

1. Perpendicular lines or segments

a. Using protractor and straightedge
b. Using straightedge and compass

2. Perpendicular bisector of a segment

a. Using protractor and ruler
b. Using compass and straightedge

3. Parallel lines or segments

a. Using protractor and straightedge
b. Using compass and straightedge

4. Dividing a segment into a given number of congruent segments

a. Using a ruler
b. Using a straightedge and compass

Vocabulary: parallel, perpendicular, transversal, alternate interior angles, corresponding angles.

Suggested Strategies

1. Again, make liberal use of industrial tools and

applications such as parallel rulers. Many students are interested in the navigational use of parallelism.

2. This is a good opportunity to introduce non-Euclidean geometry.

3. Discussion should preceed the actual constructions and should introduce the theorems of geometry, but only in an informal way. Students should be aware of the relationships that exist, but no formal presentation should be made in this course.

4. Dividing a segment into a given number of congruent segments with only a compass and straightedge is not only a useful skill, but provides an opportunity to apply the relationships concerning parallel lines, transversals, and the angles that are formed.

References

	B	G	M	SK	So2	So
Chapters	--	3,4,7	8,10	8,9	4	7

IV. Triangles

A. Classification

1. By measure of angles
2. By measure of sides

B. Parts of triangles

C. Constructions

1. Copying a triangle
2. Altitudes
3. Medians
4. Angle bisectors

D. The Pythagorean Theorem

1. Introduction
2. Square root
   a. Rational numbers
   b. Irrational numbers

3. Applications

Vocabulary: triangle, right, obtuse, acute, scalene, isosceles, equilateral, median, altitude, side, leg, hypotenuse, angle bisector, square root, irrational number, concurrence, Pythagorean Theorem, orthocenter, centroid, circumcenter, incenter, corresponding parts.

Suggested Strategies

1. Show that corresponding parts of congruent triangles are congruent by measuring both with ruler and protractor and with a compass.

2. Have students construct the altitudes, medians, angle bisectors, and perpendicular bisectors of the sides of triangles and so discover the theorems on concurrence of these parts.

3. Students enjoy locating the center of gravity of a model of a triangle. Some might build a mobile using triangle models.

4. Use plenty of problems throughout this section. So called "applied" problems are available for using the Pythagorean Theorem.

5. The Pythagorean Theorem should be introduced as a relationship between the legs and the hypotenuse of a right triangle since area has not yet been covered.

6. This is an excellent place for the introduction of irrational numbers represented as a square root. This expansion of our number system should be stressed here, although not fully developed.

References

	B	G	M	SK	So2	So
Chapters	---	3,4,7	10,11 13,14	8,9	2,4	7,9

V. Perimeter and Circumference

A. Geometric Figures

1. Classifications

a. Curves
b. Polygons
c. Quadrilaterals

2. Construction

a. Squares
b. Rectangles
c. Parallelograms
d. Hexagons

B. Perimeter

1. Polygons

2. Circles

a. Parts of circles
b. Circumference

C. Geometric designs

Vocabulary: curve, closed curve, simple closed curve, polygon, quadrilateral, pentagon, hexagon, decagon, square, rhombus, rectangle, parallelogram, trapezoid, perimeter, circumference, radius, diameter, pi, regular, convex, inscribed, circumscribed, formula.

Suggested Strategies

1. Many references are available on the historical development of Pi. These make good special assignments.

2. Students are familiar with "sets", so the development of subsets of quadrilaterals is appropriate. Example: A square is a special rectangle.

3. Try to have the students develop formulas for finding the perimeters of special polygons such as the isosceles triangle, equilateral triangle, rectangle, etc.

4. Investigate the concept of the circumference of a circle as the "limit" of the perimeter of the inscribed polygon.

5. Most students enjoy creating designs, especially those based upon a hexagon inscribed in a circle.

6. Good place to include plenty of problems to help the students strengthen their computation skills.

References

	B	G	M	SK	So2	So
Chapters	10	3,4,7	8,10,11	8,9	7	6,7,9

VI. Area and Volume

A. Area

1. Understanding the concept
2. Developing formulas

a. Rectangle
b. Square
c. Parallelogram
d. Trapezoid
e. Triangle
f. Circle

3. Applying formulas

B. Solids

1. Classification

a. Prism
b. Cylinder
c. Cone
d. Pyramid
e. Sphere

2. Surface area

C. Volume

1. Understanding the concept
2. Developing the formulas

a. Prism
b. Cylinder

c. Cone
d. Pyramid
e. Sphere

3. Applying formulas

Vocabulary: area, volume, plane figure, solid figure, surface area, prism, cylinder, cone, pyramid, sphere, apothem.

Suggested Strategies

1. Make liberal use of models. Once the Unit Area Postulate has been introduced, models of plane figures can be used. The parallelogram can be shown as a rectangle by cutting into two parts; two congruent triangles form a parallelogram, etc. This development depends upon different textbook developments.

2. For prisms, make liberal use of models such as the label of a can representing the lateral surface area of a cylinder. The "unfolding" technique is shown in virtually every textbook.

3. Again, problem solving is the objective, but the students should think it is coincidental.

4. Investigate "non-congruent" figures having the same areas.

5. The traditional models of prisms and pyramids to "discover" that $V = \frac{1}{3}bh$ is always of interest to students who have not seen it before.

References

	B	G	M	SK	So2	So
Chapters	10	2,3,4,7	9,11	8,9	7,8,9	2,6,7,9

VII. Symmetry

A. Lines of symmetry

1. Understanding the concept
2. Recognizing symmetric figures
3. Drawing lines of symmetry

Vocabulary: symmetry, axis.

Suggested Strategies

1. Use paper models and fold them to show the lines of symmetry.

2. Fold paper one or more times and cut out figures to make figures symmetric about one or more lines.

3. Use a mirror to check drawings for symmetry.

References

	B	G	M	SK	So2	So
Chapters	---	---	---	---	4	---

VIII. Similarity

A. Understanding the concept

B. Similar Polygons

1. Ratio of corresponding sides
2. Finding unknown sides using proportion

C. Applications

Vocabulary: ratio, proportion, similar, scale drawing, indirect measurement.

Suggested Strategies

1. 1. A study of maps acquaints the student with the use of proportion and its practical application.

2. Architectural drawings are another application of similar figures which interest many students.

3. Again, use problem solving as much as possible to reinforce computational skills.

References

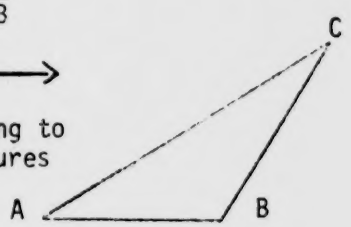
	B	G	M	SK	So2	So
Chapters	9	8,10	12,13	9	7,8,9	6,7,9

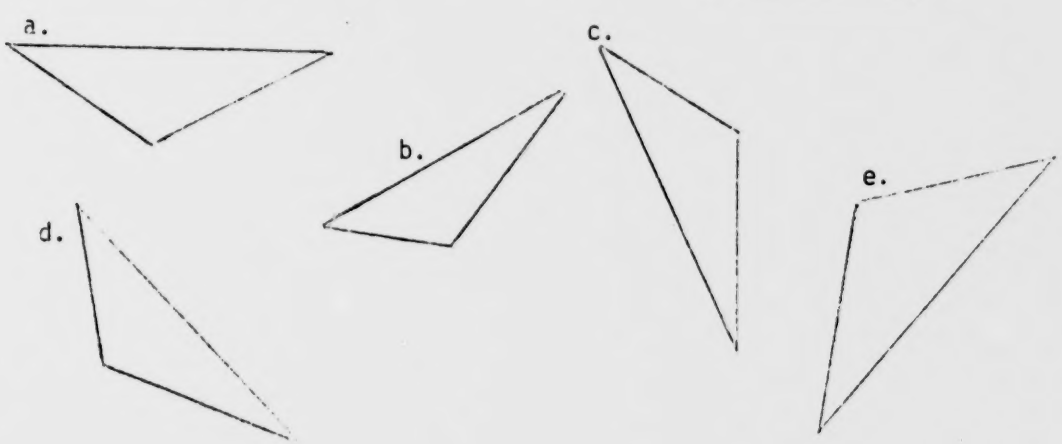
SAMPLE TEST ITEMS
(keyed to objectives)

I. 1. Match one of the symbols or models in Column B with each of the words in Column A.

Column A	Column B
a. half plane	1. $\angle$
b. point	2.
c. ray	3. •
d. segment	4. $\overrightarrow{MN}$
e. half line	5. ST
f. angle	6.
g. plane	7.
h. line	8.
	9. $\overline{AB}$
	10.

2. Trace triangle ABC and use the tracing to determine which of the following figures are congruent to $\triangle$ ABC.





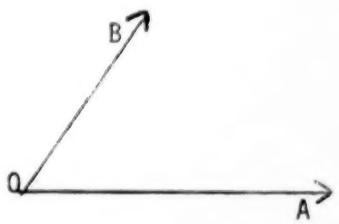
3. a. Use a ruler to draw $\overline{CD}$ congruent to $\overline{AB}$, then find
& and label point E so that E bisects $\overline{CD}$.
4.

A B

b. Use a compass and straightedge to construct $\overline{PQ}$ congruent to $\overline{MN}$, then bisect $\overline{PQ}$ and label the midpoint R. Show all construction marks.

M N

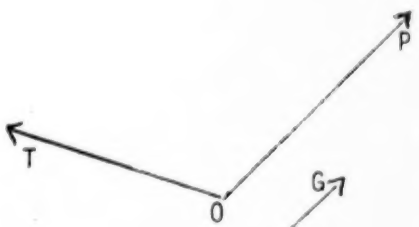
II. 1. Copy $\angle$ AOB.



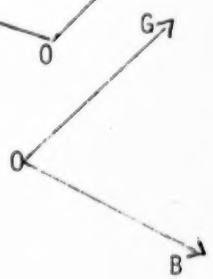
a. Use a protractor and straightedge.

b. Use a compass and straightedge. Show all construction marks.

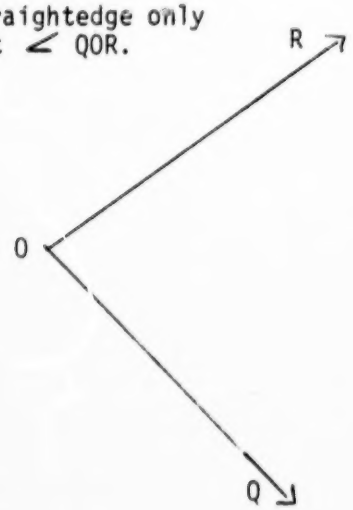
2. a. Use a protractor and straightedge to bisect $\angle$ TOP.



b. Use a compass and straightedge to bisect $\angle$ GOB. Show all construction marks.



c. Use a straightedge only to bisect $\angle$ QOR.



3. Trisect $\angle$ NOM.

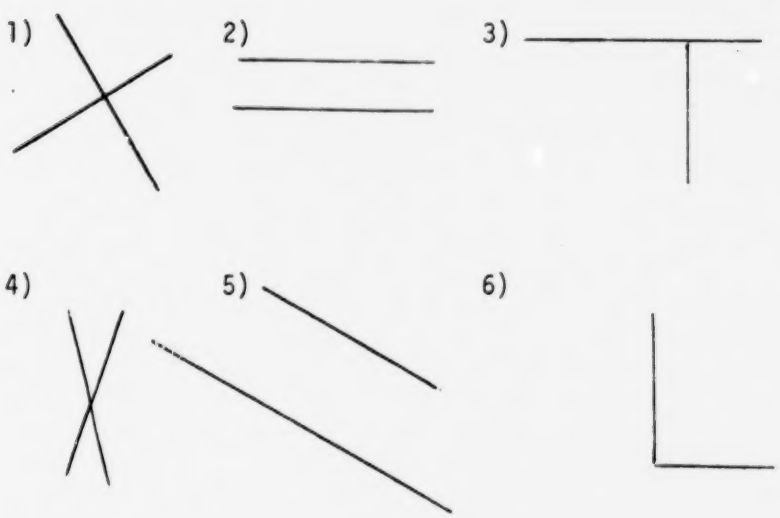
4. $\angle$ A and $\angle$ B are supplementary angles.

   $\angle$ B and $\angle$ C are complementary angles.

   If $\angle$ A = 155°, what is the measure of $\angle$ C?

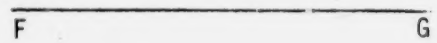
III. 1. a. Which of the following drawings are models of parallel segments?

   b. Which of the following drawings are models of perpendicular segments?



2. a. Use a protractor and ruler to construct the perpendicular bisector of $\overline{AB}$.

b. Use a compass and straightedge to construct the perpendicular bisector of $\overline{FG}$. Show all construction marks.



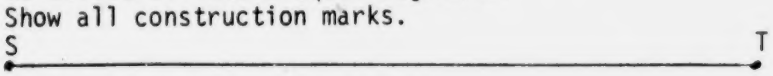
3. a. Use a protractor and straightedge to construct two segments that are perpendicular.

b. Use a compass and straightedge to construct a segment through point A that is perpendicular to $\overline{MN}$. Show all construction marks.

4. a. Use a protractor and straightedge to construct a line parallel to $\overleftrightarrow{AB}$.

b. Use a compass and straightedge to construct a segment parallel to $\overline{KL}$. Show all construction marks.

5. Use a compass and straightedge to divide $\overline{ST}$ into 3 equal segments. Show all construction marks.



Iv. 1. Classify each triangle described below as acute, obtuse, right, scalene, equilateral or isosceles.

In $\triangle ABC$:

a. $\angle A = 90°$

b. $\overline{AB} = \overline{AC}$

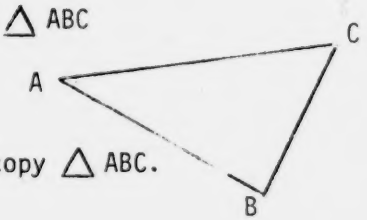
c. $\angle A = 20°$ and $\angle C = 85°$

d. $\overline{AB} = \overline{BC} = \overline{CA}$

e. $\angle C > 120°$

f. $\overline{AB} \neq \overline{AC}$, $\overline{AB} \neq \overline{BC}$, and $\overline{AC} \neq \overline{BC}$

2. a. Use a ruler and protractor to copy $\triangle ABC$



b. Use a compass and straightedge to copy $\triangle ABC$. Show all construction marks.

3. Solve the following problems.

a. In right triangle ABC with $\angle C = 90°$, if $c = 17$ and $b = 8$, then $a = ?$

b. Find the length of a diagonal of a square whose sides are each 5 inches.

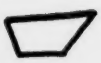
c. How high up on a building will a 30 foot ladder reach if the lower end of the ladder is placed 9 feet from the base of the building?

V. 1. Name each of the following geometric figures. Do not use the same name twice.

a.

b.

c.

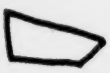
d. 

e.

f.

g.

h.

i. 

j.

k.

l.

m.

n.

2. a. Use a ruler and protractor to construct:

   (1) a square
   (2) a rectangle
   (3) a parallelogram
   (4) a hexagon

   b. Use a compass and straightedge to construct:

   (1) a square
   (2) a rectangle
   (3) a parallelogram
   (4) a hexagon

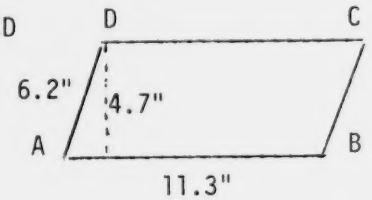
   Show all construction marks.

3. Find the perimeter of a triangle whose sides measure $2\frac{1}{4}$", $5\frac{1}{2}$" and $3\frac{5}{8}$".

4. Find the circumference of a circle whose radius is 3.6 inches.

VI. 1. a. Find the area of a triangle whose base is 6" and whose altitude is $5\frac{1}{2}$".

b. Find the area of ABCD



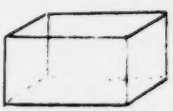
2. Name each of the following solid figures.

a.

b.

c.

d.

e. 

3. a. Find the surface area of a rectangular prism whose dimensions are $2\frac{3}{4}$", 4", and $7\frac{1}{2}$".

b. A croquet ball is 3" in diameter. Find its surface area.

4. a. A right circular cylinder has a radius of 5" and a height of 8". Find its volume.

b. The base of a pyramid is a right triangle whose legs measure 8" and 6". The altitude of the pyramid is 11". Find its volume.

VII. 1. Which of the following figures have at least one axis of symmetry?

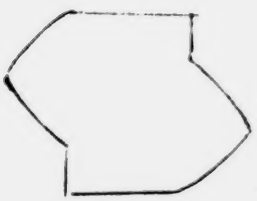
a.

b.

c.

d.

e.



f.

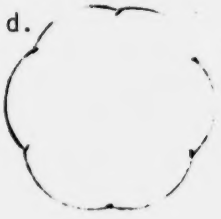
2. Draw one line of symmetry of each of the following figures.

a.

b.

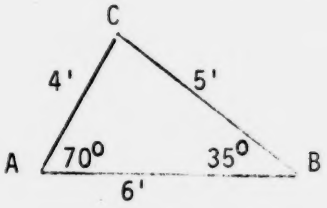
c.

d.



VIII. 1. Which of the figures described below are similar to the figure at the right?

a. A triangle whose sides are 3", 2", and 2 $\frac{1}{2}$".



b. A triangle in which $\angle H = 75^{\circ}$ and $\angle E = 35^{\circ}$

c. A triangle in which one side measures 8', another side measures 12', and an angle measures 35°.

d. A triangle that has two of its sides in the ratio 5:6.

2. a. A 10 foot lamp post casts a shadow of 6 feet at the same time a tree casts a shadow of 24 feet. How tall is the tree?

b. If $\triangle ABC \sim \triangle DEF$, and a = 8, d = 5, b = 20, what is the length of e?

KEY TO TEST ITEMS
(Constructions excluded)

I. 1. a. 6 b. 3 c. 7 d. 9 e. 4 f. 1 g. 2 h. 10

2. a, c, d

II. 4. $\measuredangle C = 65^{\circ}$

III. 1. a. 2, 5 b. 1, 3, 6

IV. 1. a. right b. isosceles c. acute

d. equilateral 3. obtuse f. scalene

3. a. a = 15 b. $\sqrt{50} \approx 7.1$ inches c. $\sqrt{819} \approx 28.6$ feet

V. 1. a. square b. closed curve c. triangle d. trapezoid

e. circle f. hexagon g. simple closed curve

h. rhombus i. quadrilateral j. rectangle k. decagon

l. parallelogram m. pentagon n. polygon

3. $11\frac{3}{8}$"

4. 22.6" approximate

VI. 1. a. $16\frac{1}{2}$ in.^{2} b. 53.11 in.^{2}

2. a. cylinder b. sphere c. pyramid d. cone e. prism

3. a. $123\frac{1}{4}$ in.^{2} b. 28.26 in.^{2}

4. a. 628 in.^{3} b. 88 in.^{3}

VII. 1. a, b, c, f

VIII. 1. a, b

2. a. 40 feet b. e = 12.5

ANNOTATED BIBLIOGRAPHY

7J-IP-4, Introduction to Geometry. Dade County Schools, Department of Program Planning and Development. Some supplementary materials for use with angles.

Brown, et al. Introduction to High School Mathematics. River Forest, Illinois: Laidlaw Brothers, 1970. Chapter 1 only. Very good with all units. Includes constructions and problems.

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Gundlach, et al. Junior High School Mathematics, 7 and 8. River Forest, Illinois: Laidlaw Brothers, 1968. Very good for supplementary exercises.

Nichols, et al. Mathematics Patterns and Structures. New York, N. Y.: Holt, Rinehart and Winston, Inc., 1968. Chapter 4. Good supplementary exercises for constructions.